Electricity Price Prediction Equation

Department for Energy Development and Independence
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DRAFT

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Purpose of this project

The purpose of this project is to analyze the relationships between historical electricity portfolios and electricity prices across the contiguous United States to estimate the most-likely electricity price in a state with a portfolio and other conditions that the user has specified. We are trying to predict the price of electricity using portfolio data, and we can do it successfully 96% of the time.

Data Collection

In this energy database, we have 3647 observations from 1940 to 2010 of all 50 U.S. states. Each observation contains coal price, gas price, and all relevant variables. But most of the data are missing from 1940 to 1989. So, in this model we only use the 895 complete data from 1990 to 2009.

Variable Description

varaible	description
rate	the price of electricity
coal	the percentage of electricity generation that is from coal
hydro	the percentage of electricity generation that is from hydro
gas	the percentage of electricity generation that is from gas
nuke	the percentage of electricity generation that is from nuke
wind	the percentage of electricity generation that is from wind
biomass	the percent of electricity generation that is from biomass
ngeid	the price of gas
gas-ngeid	an interaction term of ngeid and gas
cleid	the price of coal in dollar per MMBTU in that state
estcp-pc	per capita electricity consumption in Gigawatt hours

Working Model

Random Coefficient model.

$$Y_{ij} = \underbrace{X_i \times \beta}_{\text{Fixed Effect}} + \underbrace{Z_i \times \gamma_i}_{\text{Random Coefficient}} + \varepsilon_{ij}$$

with $\varepsilon_{ij} \sim N(0, \sigma^2)$

Fixed Effect

$$X_i \times \beta = \text{int}_\beta + \beta_1 \times \text{year} + \beta_2 \times \text{coal} + \cdots + \beta_{11} \times \text{estcp\_pc}$$

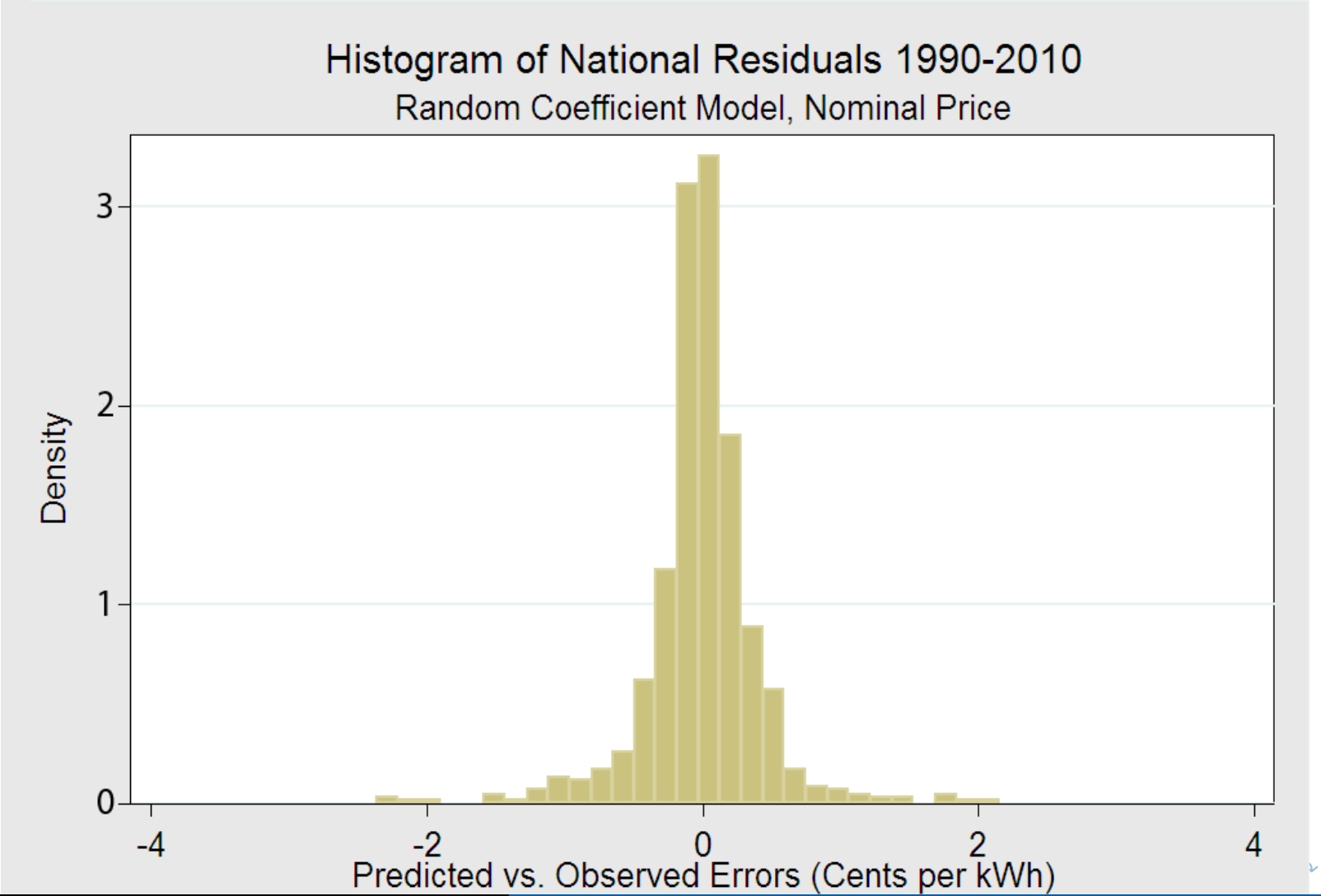
Random Coefficient

$$Z_i \times \gamma_i = \text{int}_{\gamma_i} + \gamma_{1i} \times \text{coal} + \gamma_{2i} \times \text{ngeid} + \gamma_{3i} \times \text{cleid}$$

Without this part, this model will be the fixed effect model, which we used initially.

residual

Of 895 historical estimates, 860 were within 1 penny of the observed value, which is approximately 96%. 891 were within 2 pennies of the observed value. No estimates are larger than 2.5 pennies away from the observed value. While for the fixed effect model, only about 837 were within 1 penny of the observed value.


Histogram of National Residuals 1990-2010
Random Coefficient Model, Nominal Price
Density
0
1
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Predicted vs. Observed Errors (Cents per kWh)

Fixed Effect Estimation

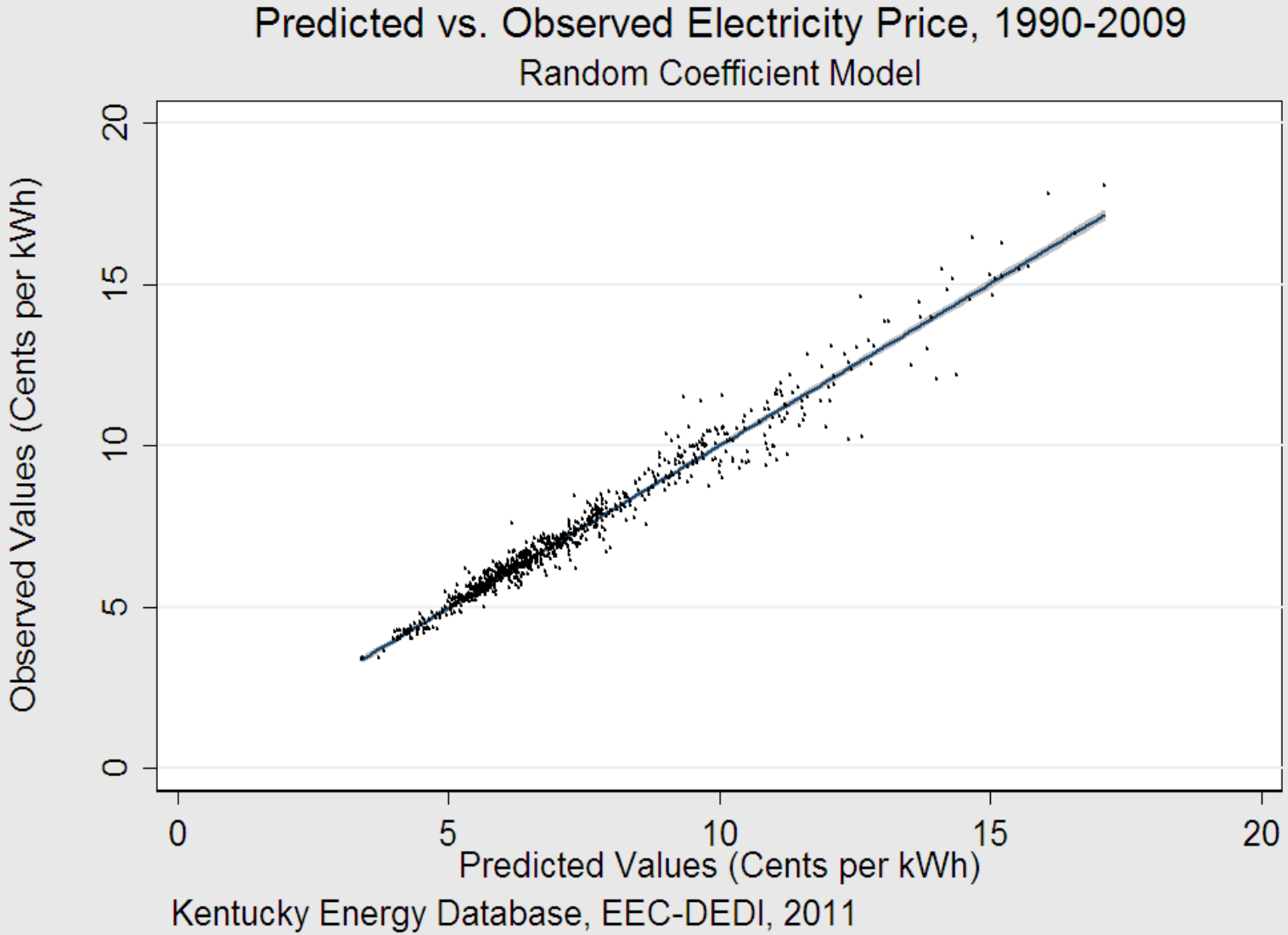
Fixed Effect	Estimation	p-value
Intercept	-131.15	<0.0001
year	0.06761	<0.0001
coal	2.7068	0.0002
cleid	1.518	<0.0001
hydro	2.1837	0.0073
gas	2.4701	0.0005
ngeid	-0.02761	0.1796
gas_ngeid	0.5362	<0.0001
nuke	3.2372	<0.0001
wind	11.3215	<0.0001
biomass	16.2255	<0.0001
estcp_pc	-172.85	<0.0001

Advantage of random coefficient model

- **Accuracy** Since this model is a subject specified model, it can cause less variation compared to fixed effect model.
- **Data-Driven** All of the coefficients in this model were derived from historical Federal data using statistical procedures.
- **Validation** This model has been validated using historical data from the contiguous United States. If things continue as they have over the past twenty years, then these results are very likely.

Disadvantage of random coefficient model

- **Complexity** This model involves advanced mathematical procedures and is more difficult to communicate or understand.
- **No New Technologies** Since the model uses historical observations, it can not simulate experimental or theoretical electricity generating technologies, where data is not yet available.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Random Coefficient Model
Observed Values (Cents per kWh)
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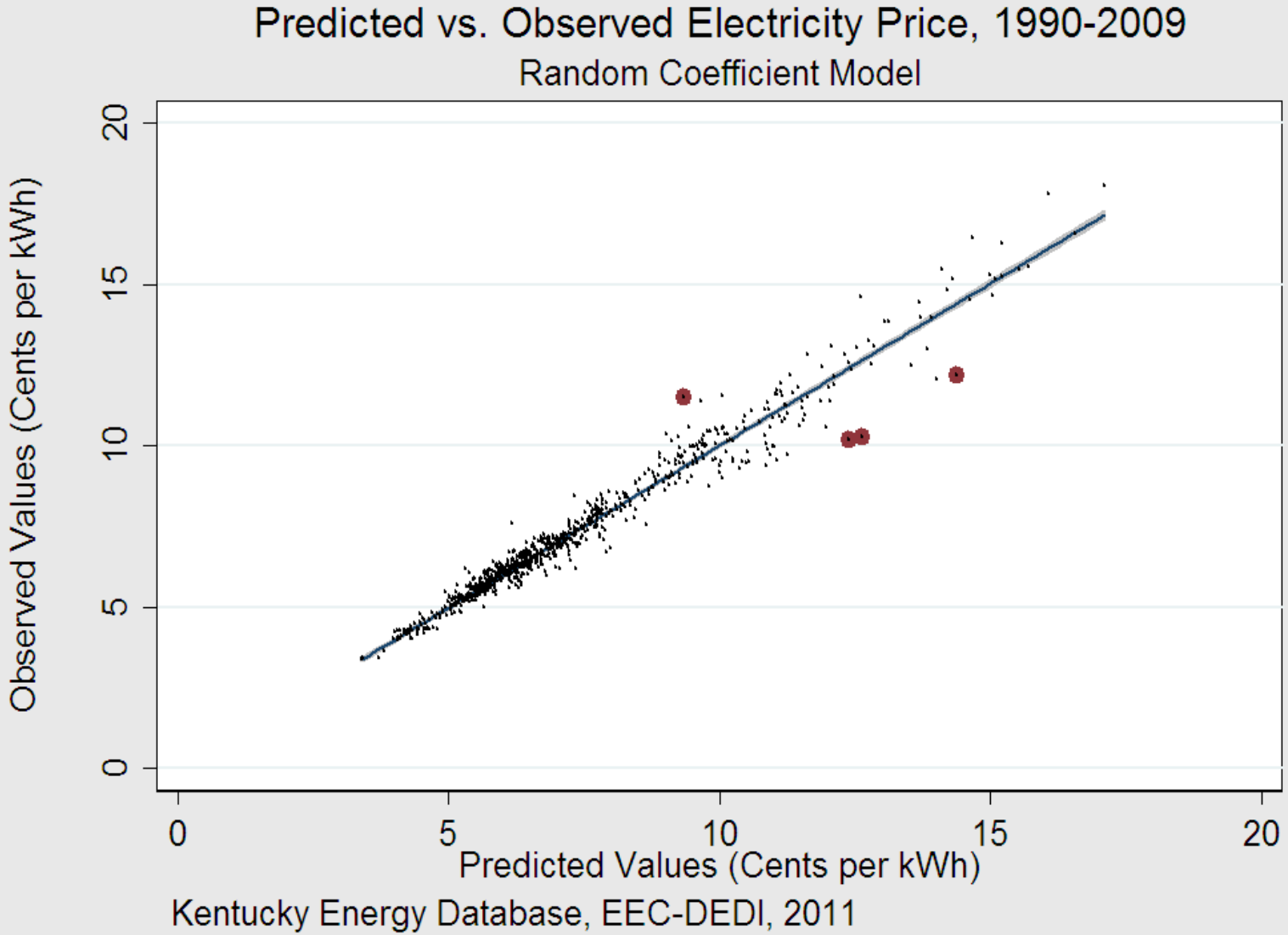
Predicted Values (Cents per kWh)
Kentucky Energy Database, EEC-DEDI, 2011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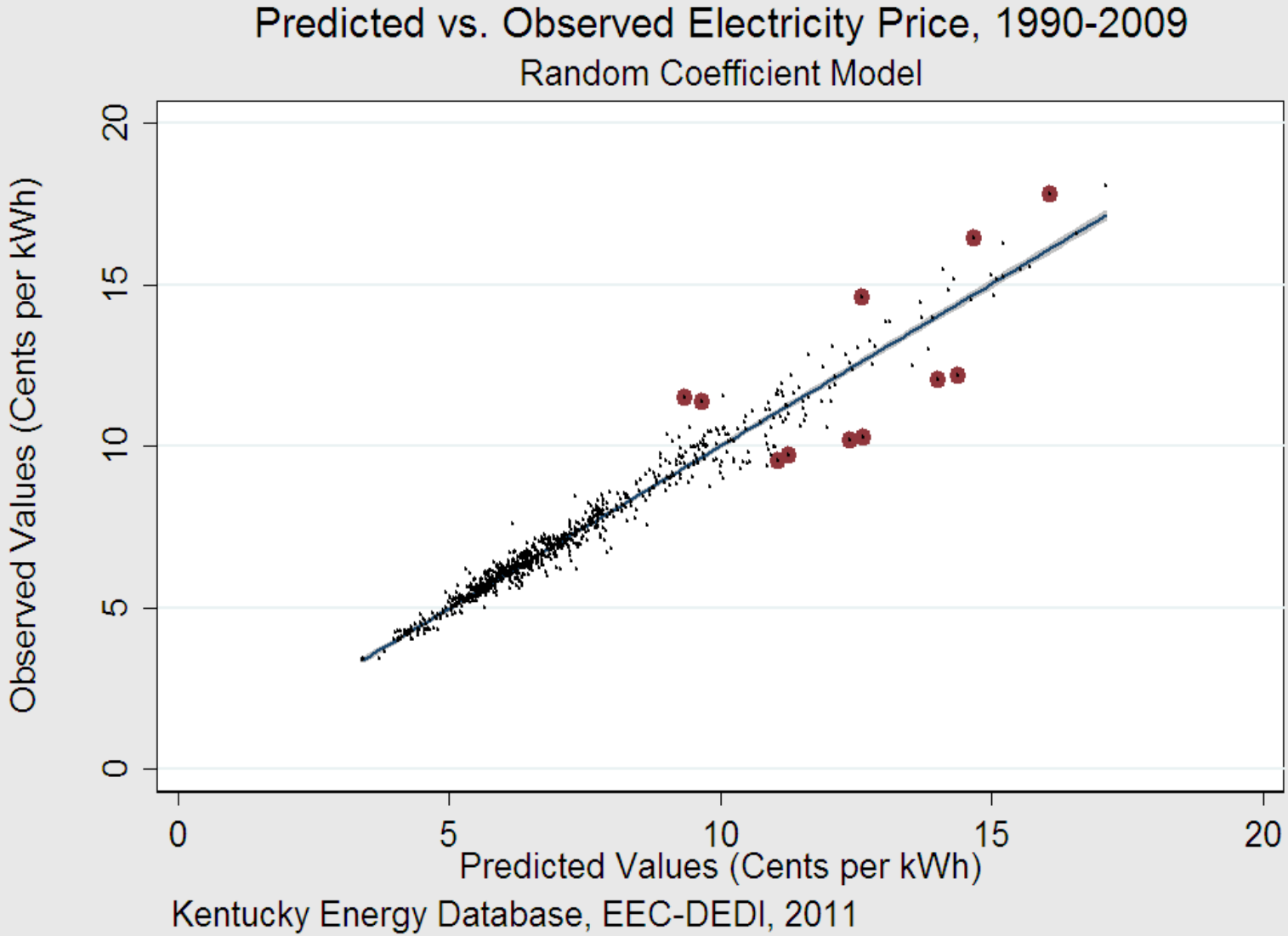
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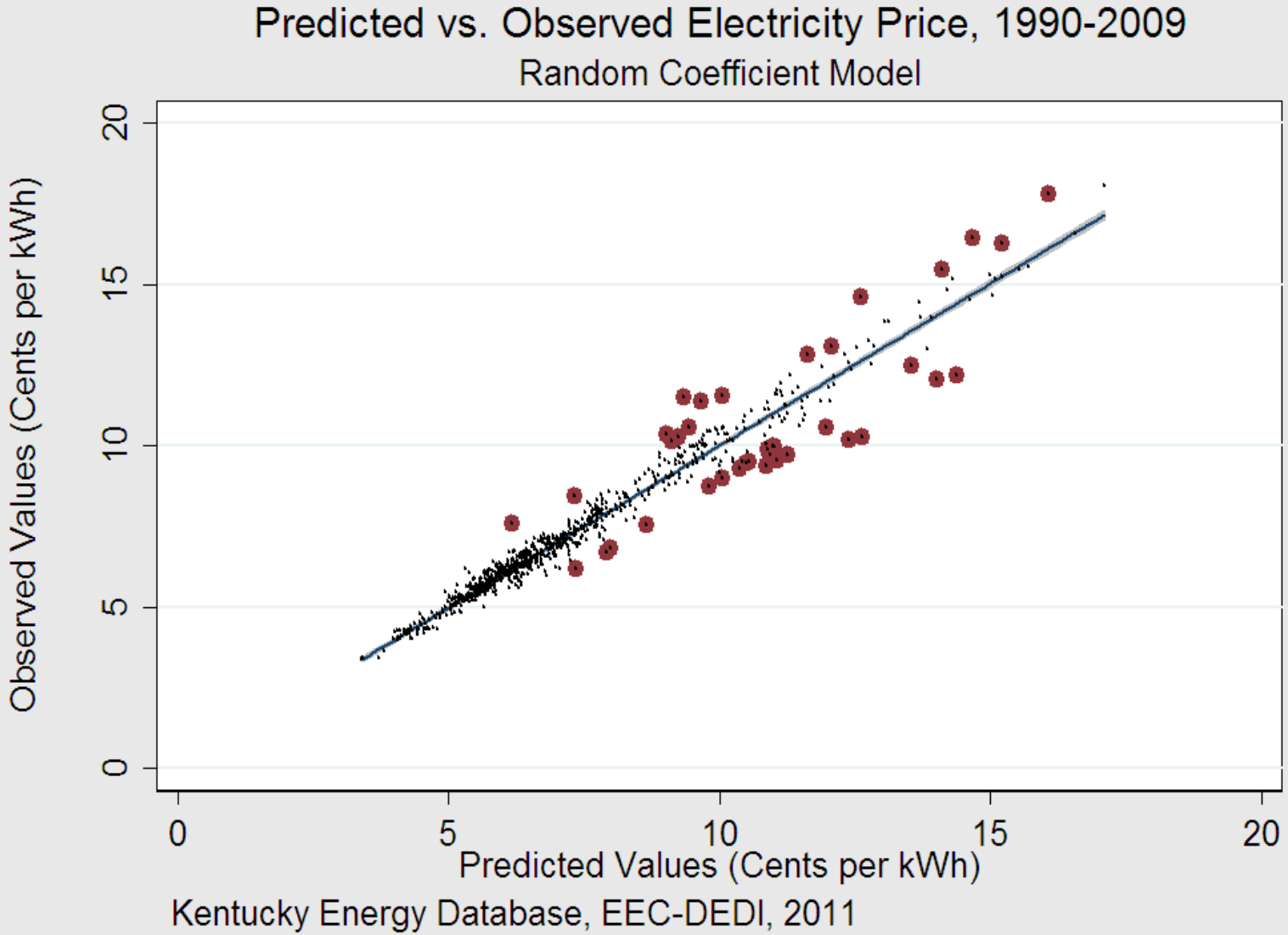
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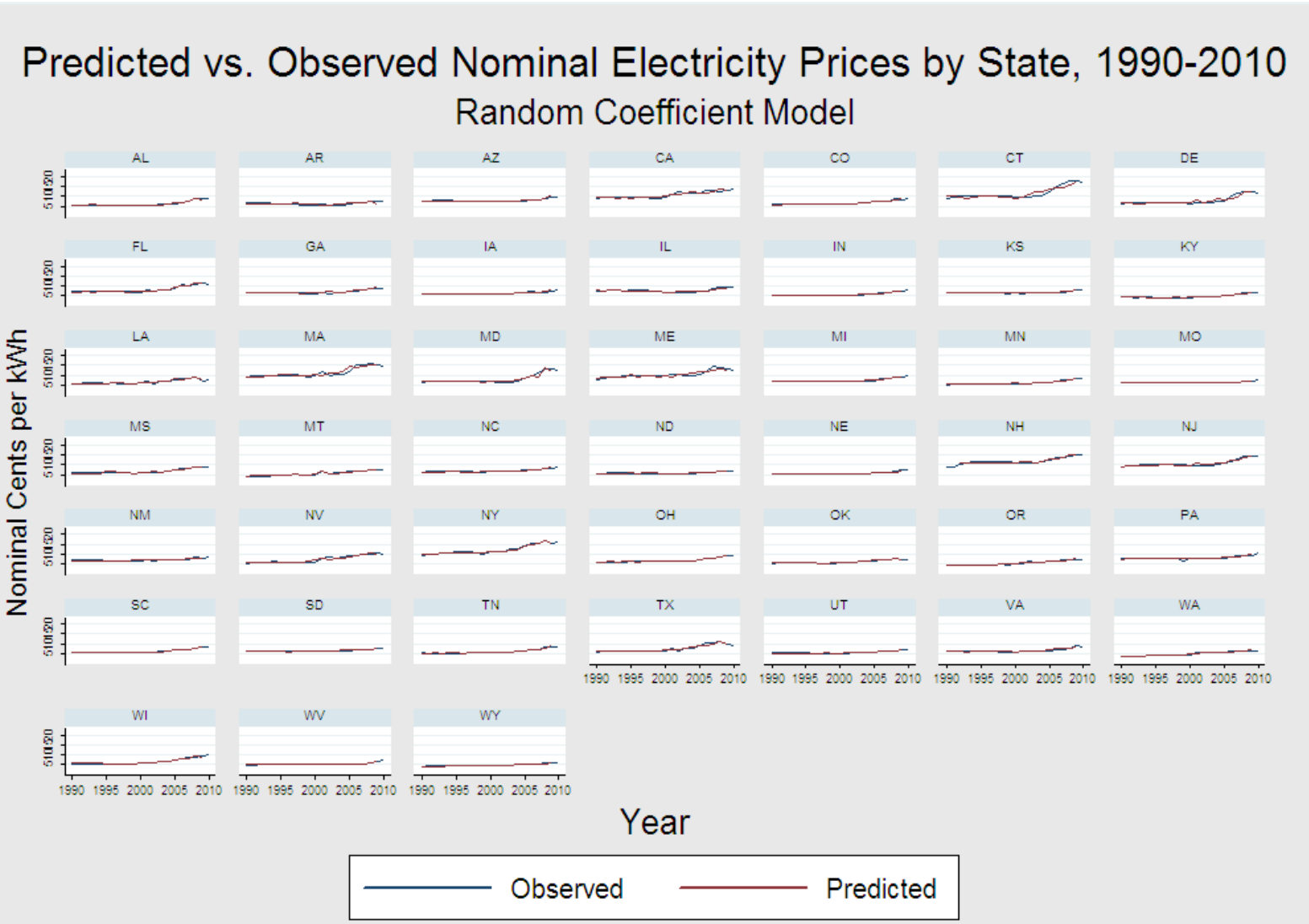
Predicted vs. Observed Nominal Electricity Prices by State, 1990-2010
Random Coefficient Model
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Nominal Cents per kWh
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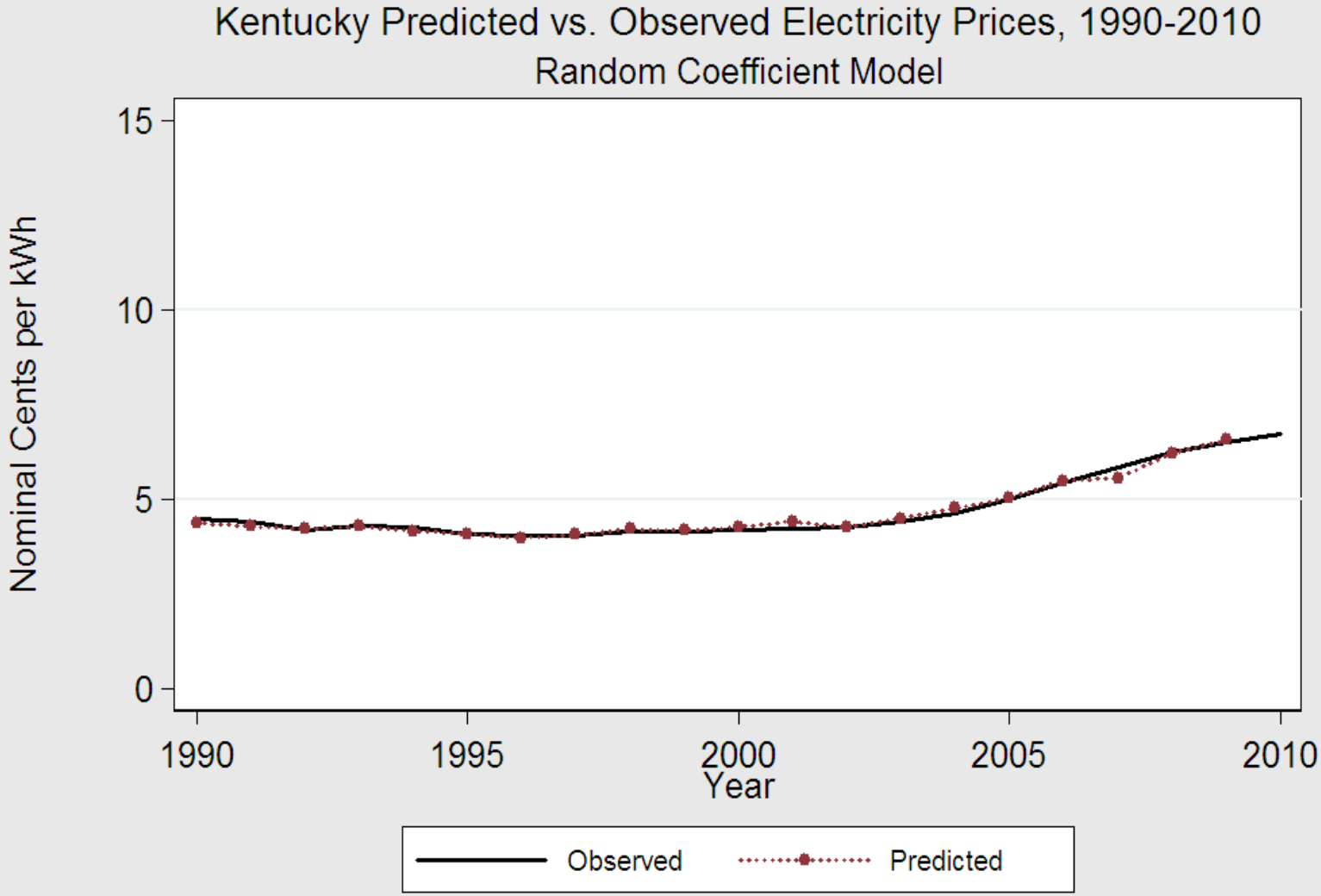
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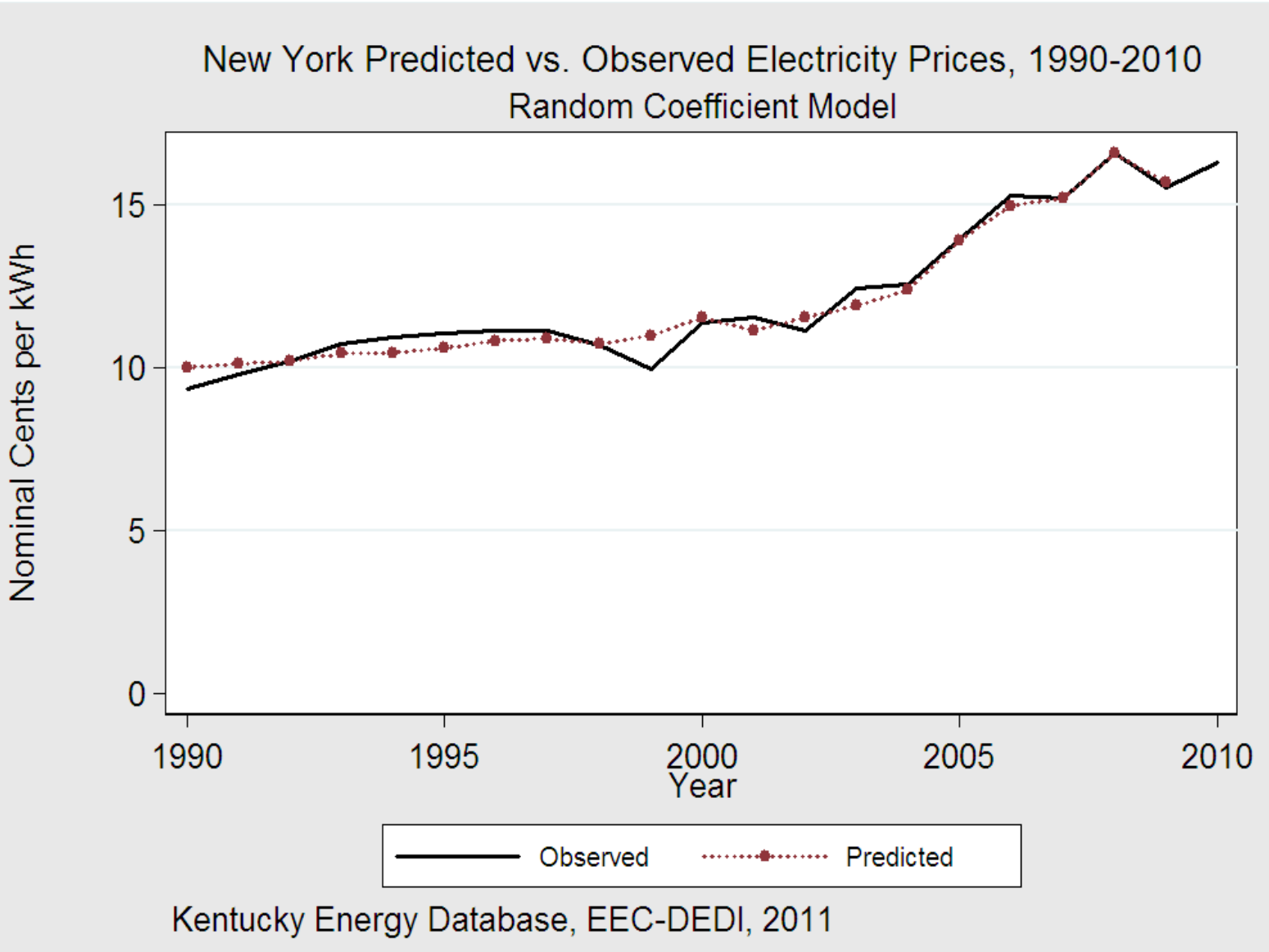
New York Predicted vs. Observed Electricity Prices, 1990-2010
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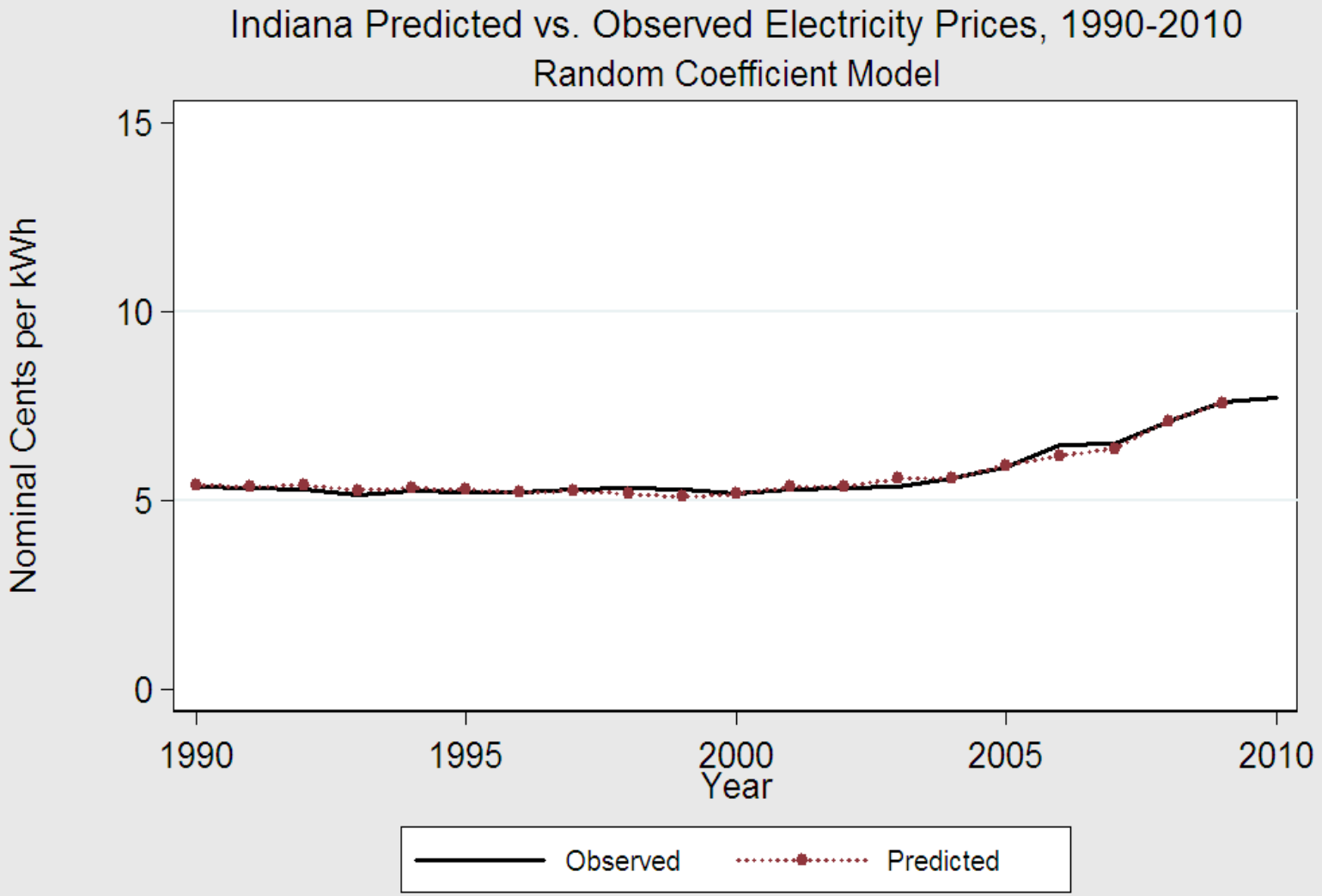
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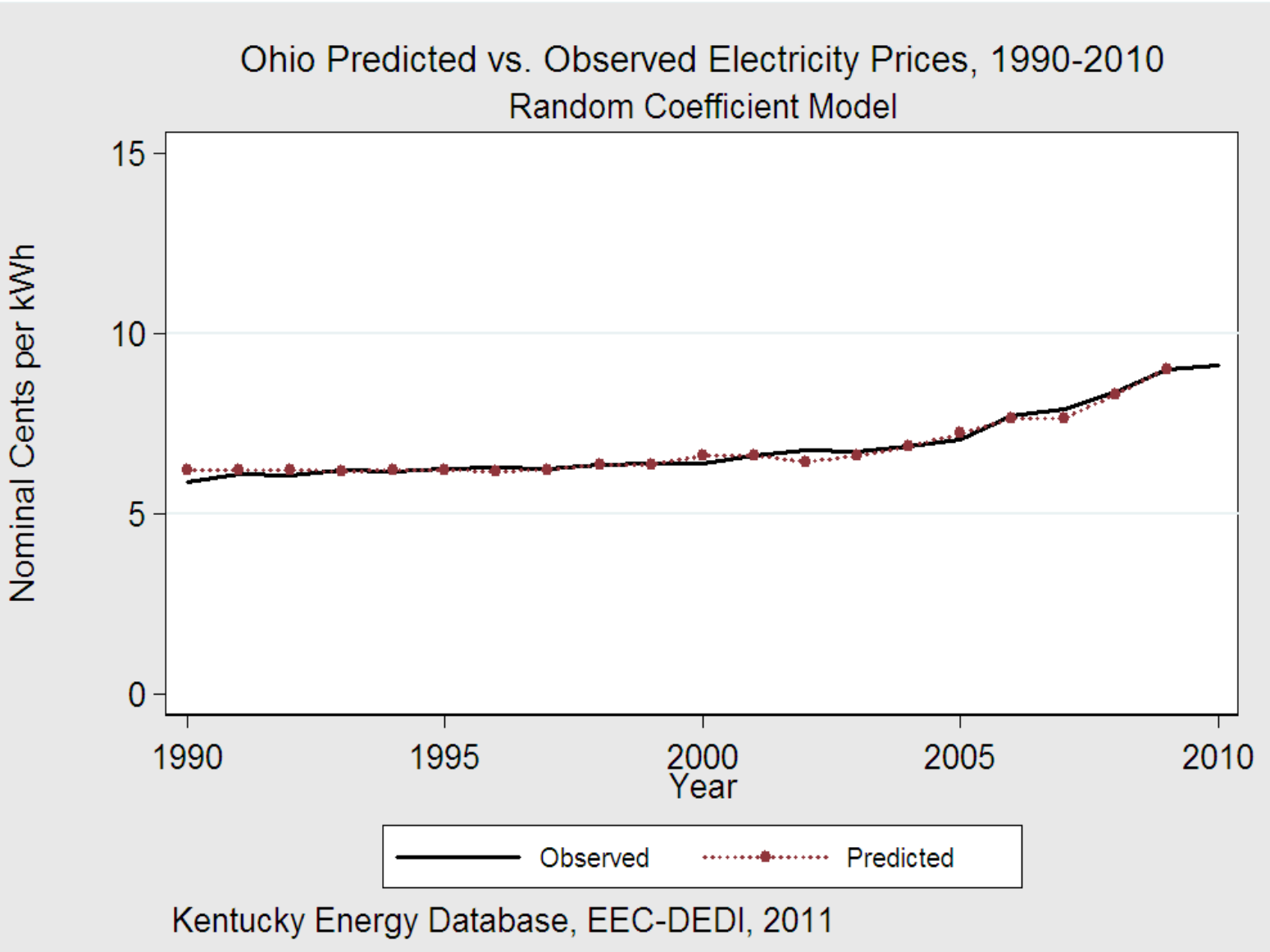
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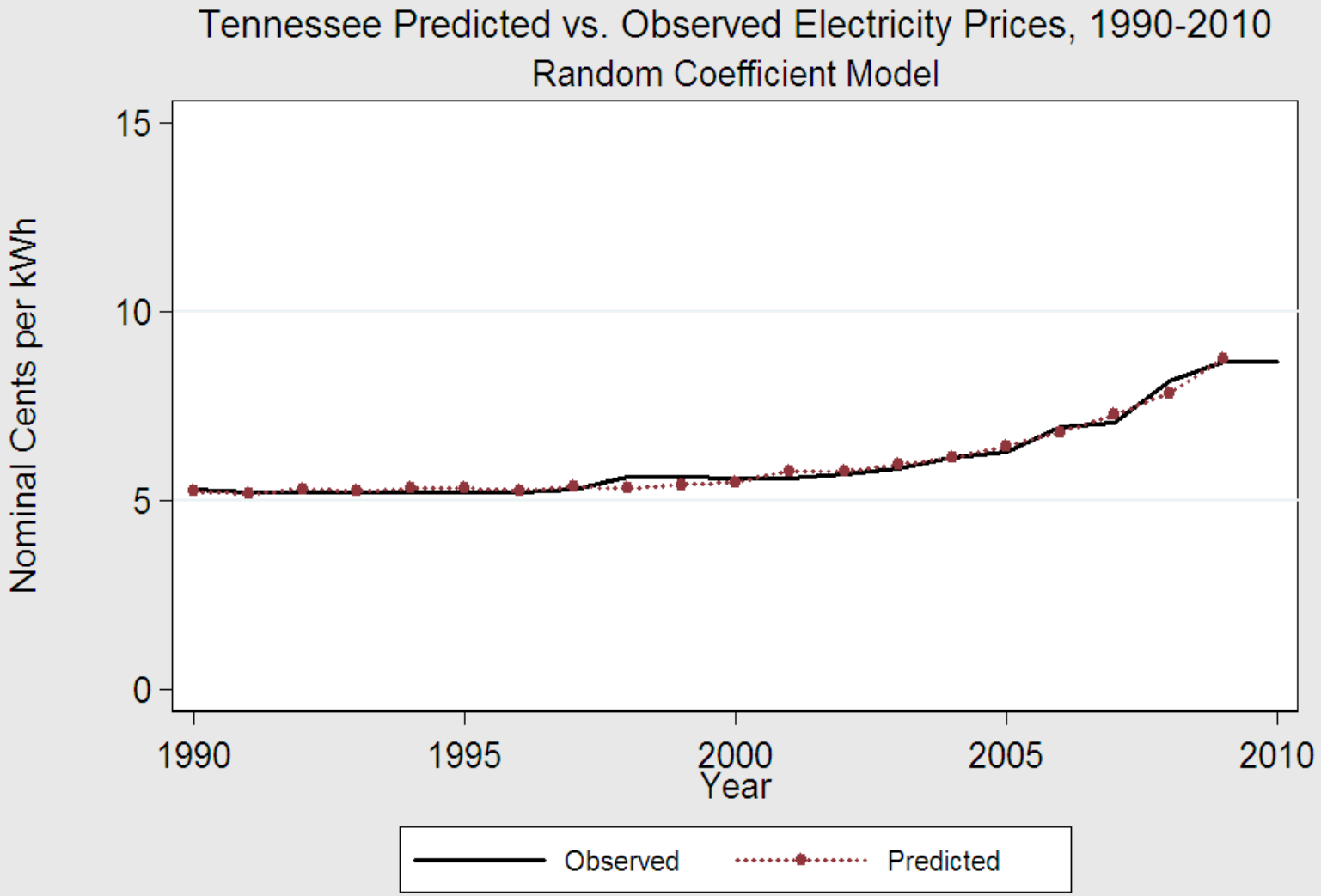
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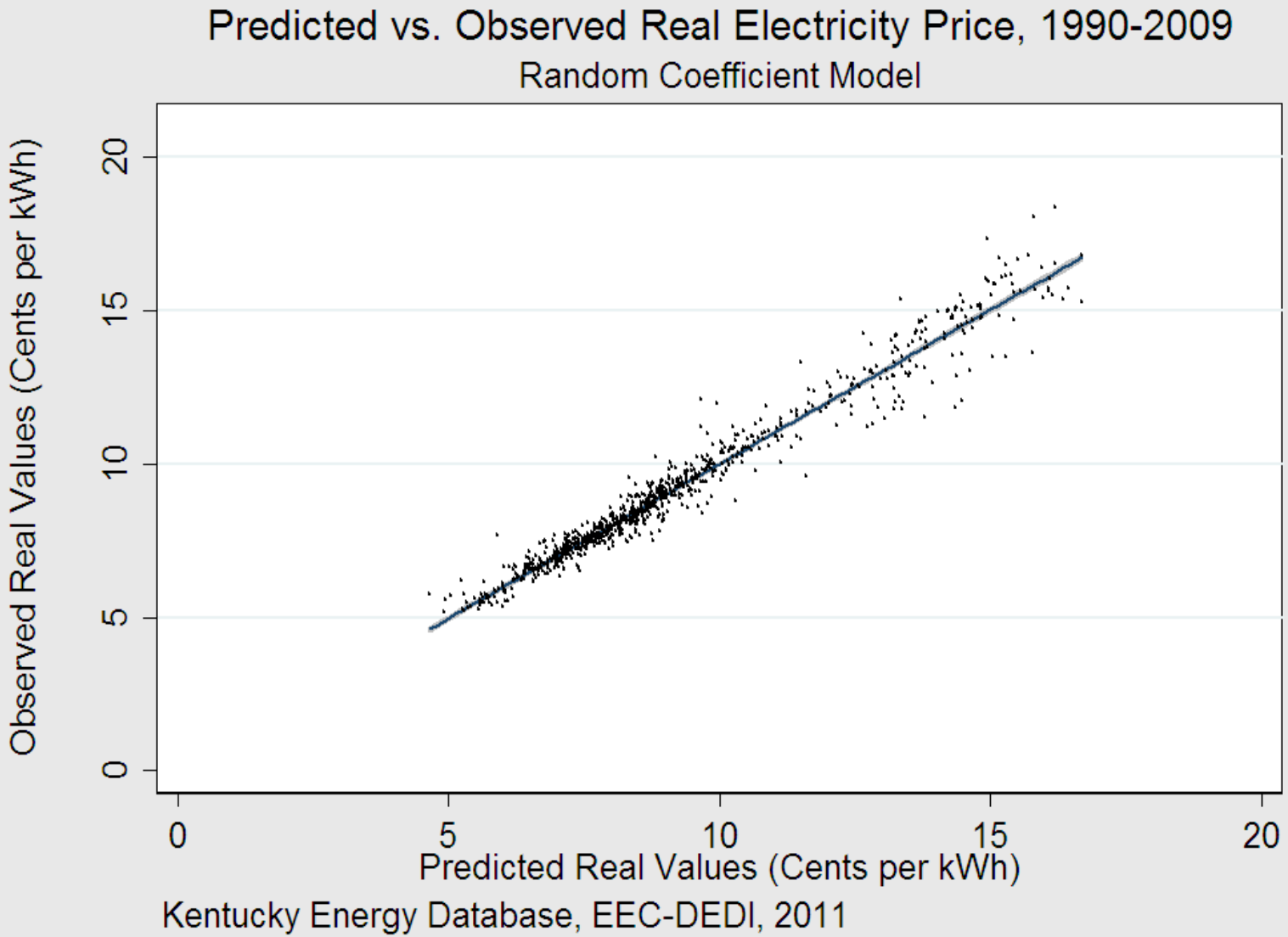
Predicted vs. Observed Real Electricity Price, 1990-2009
Random Coefficient Model
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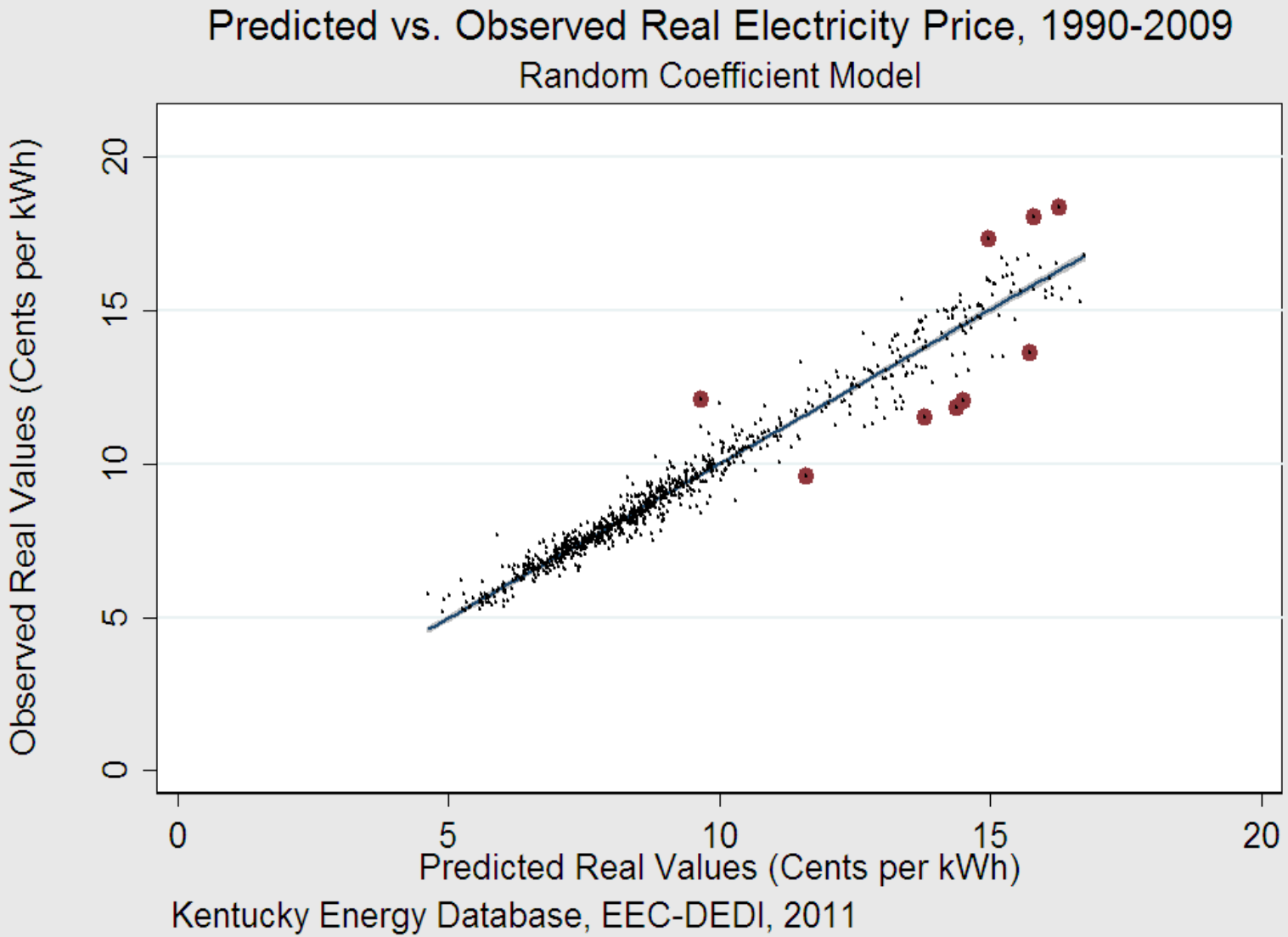
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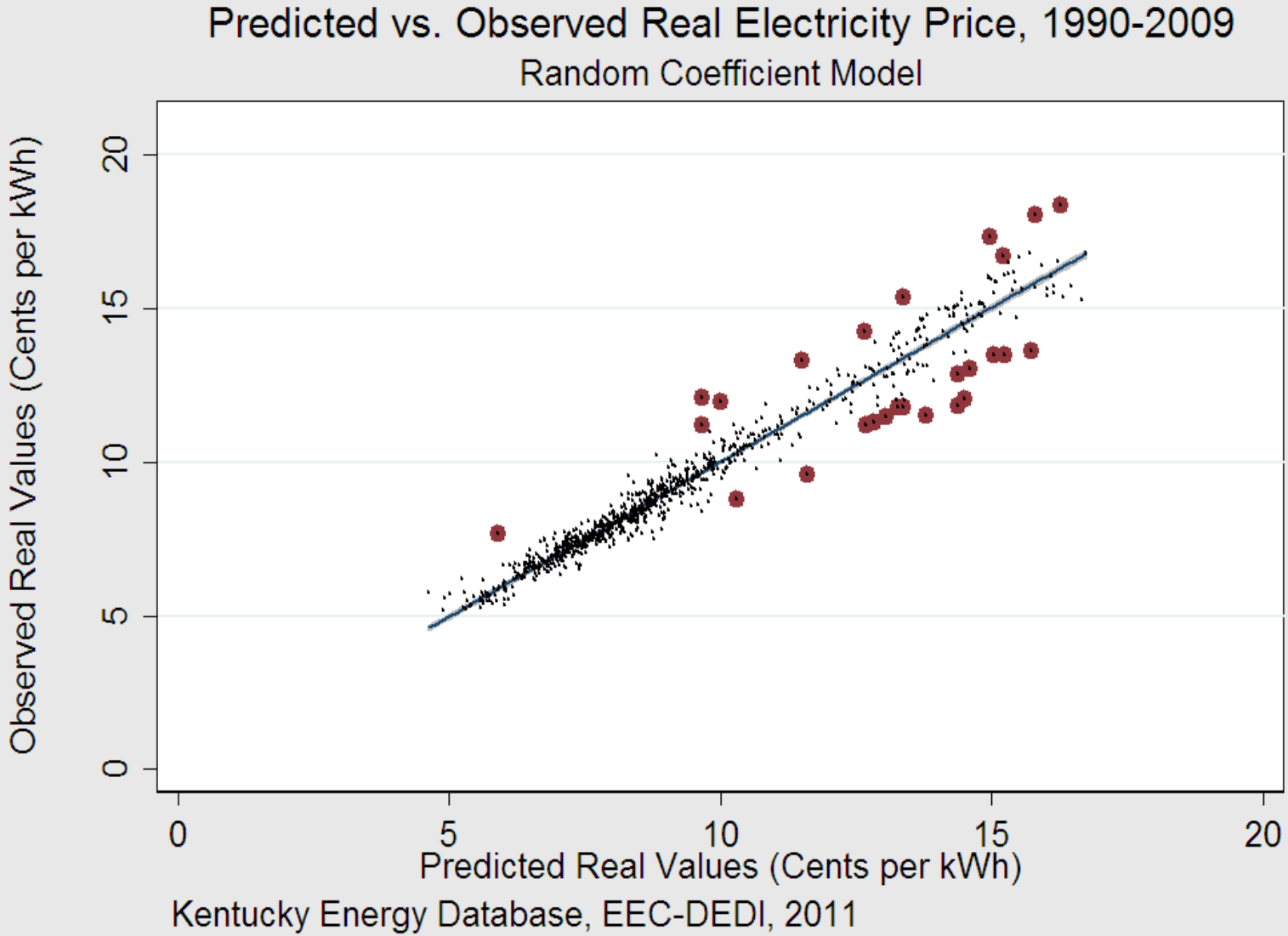
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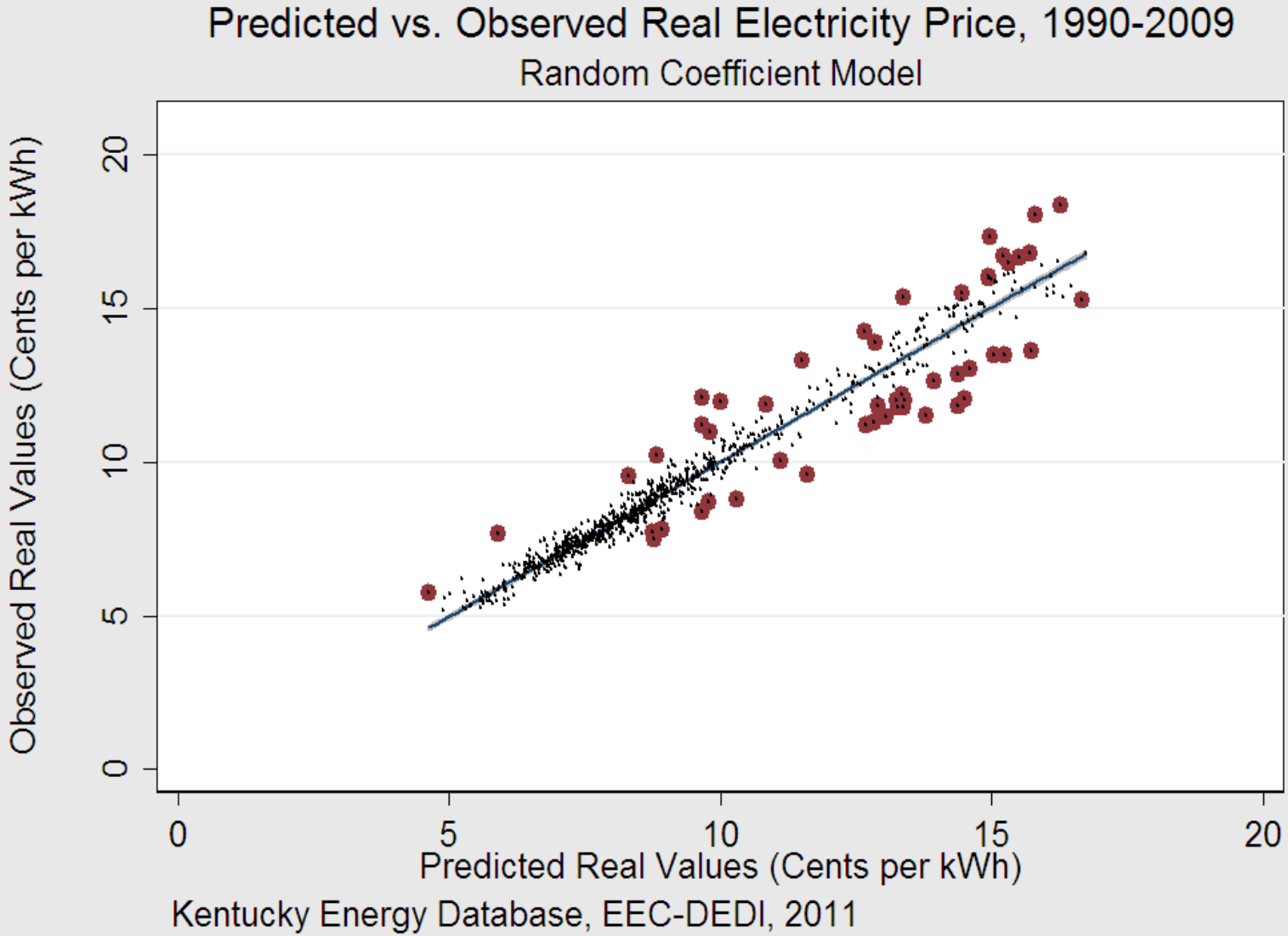
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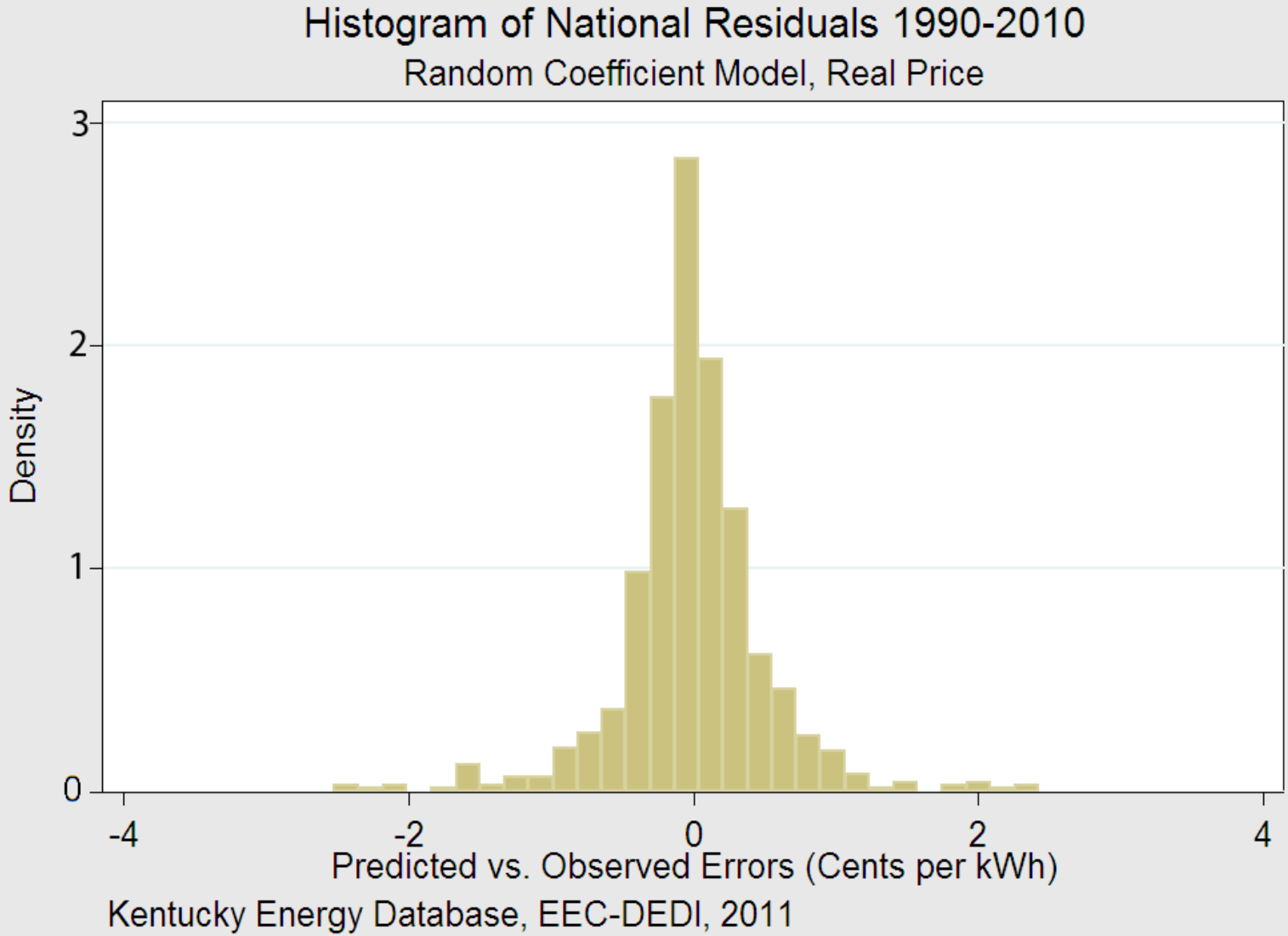
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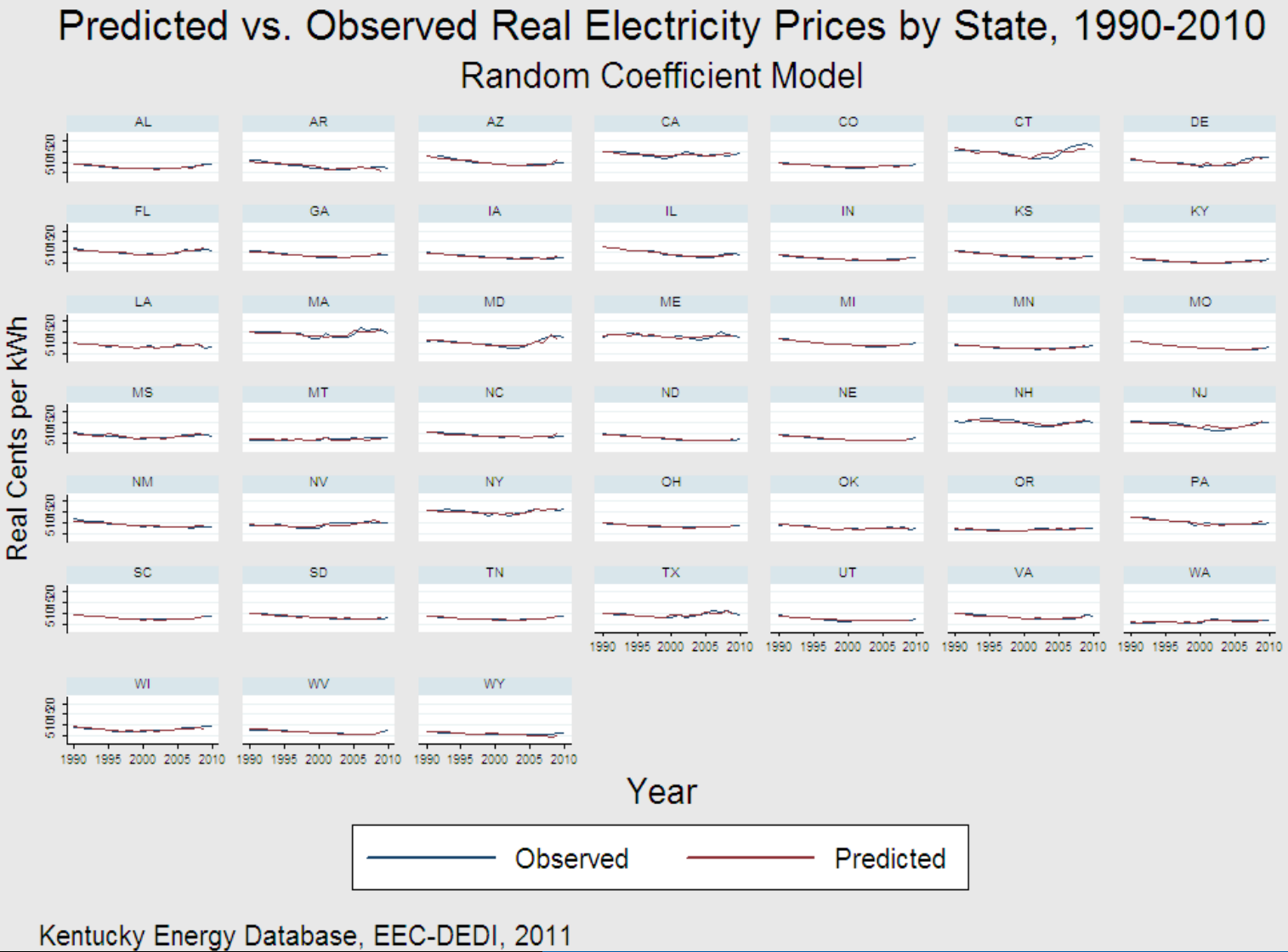
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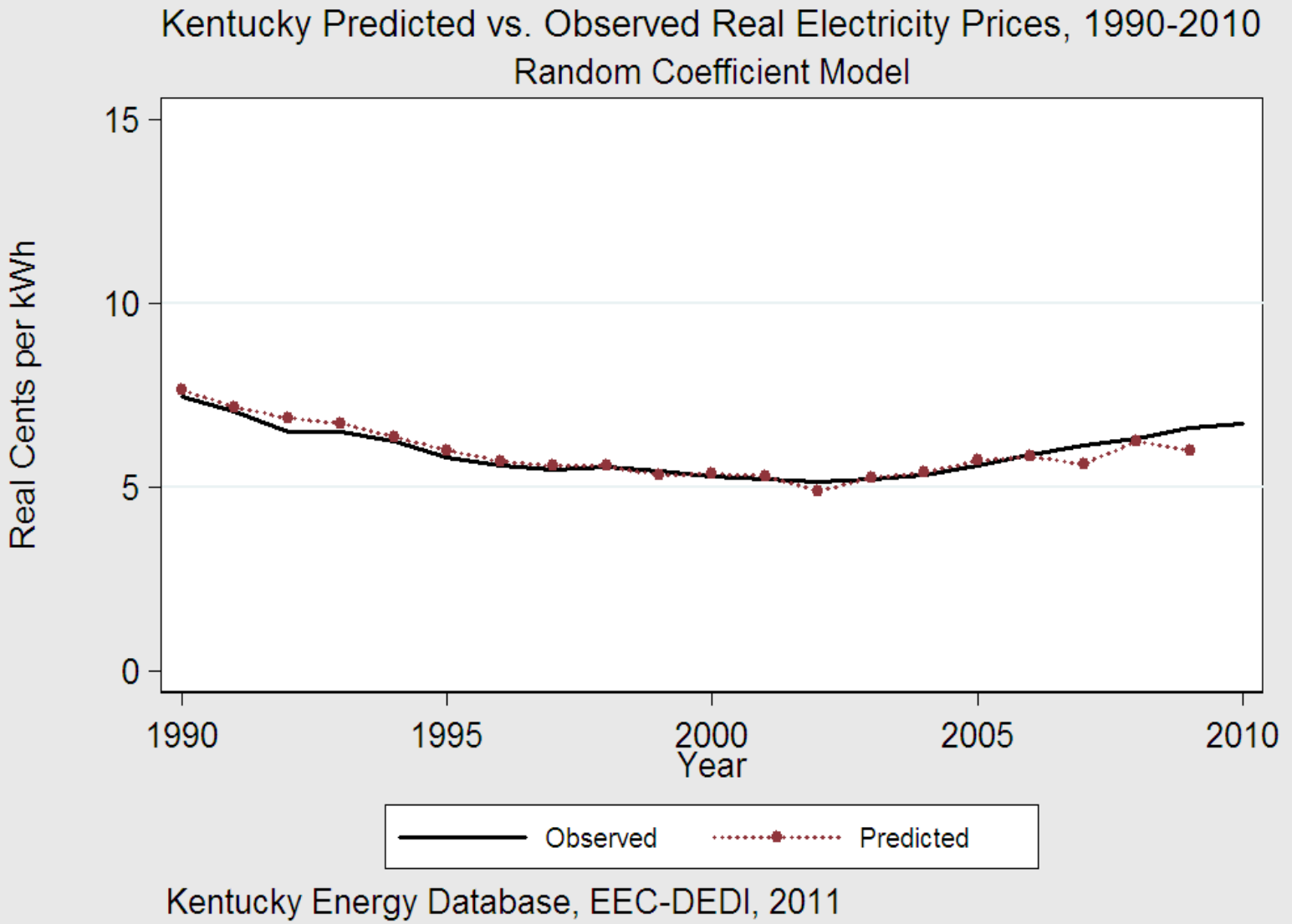
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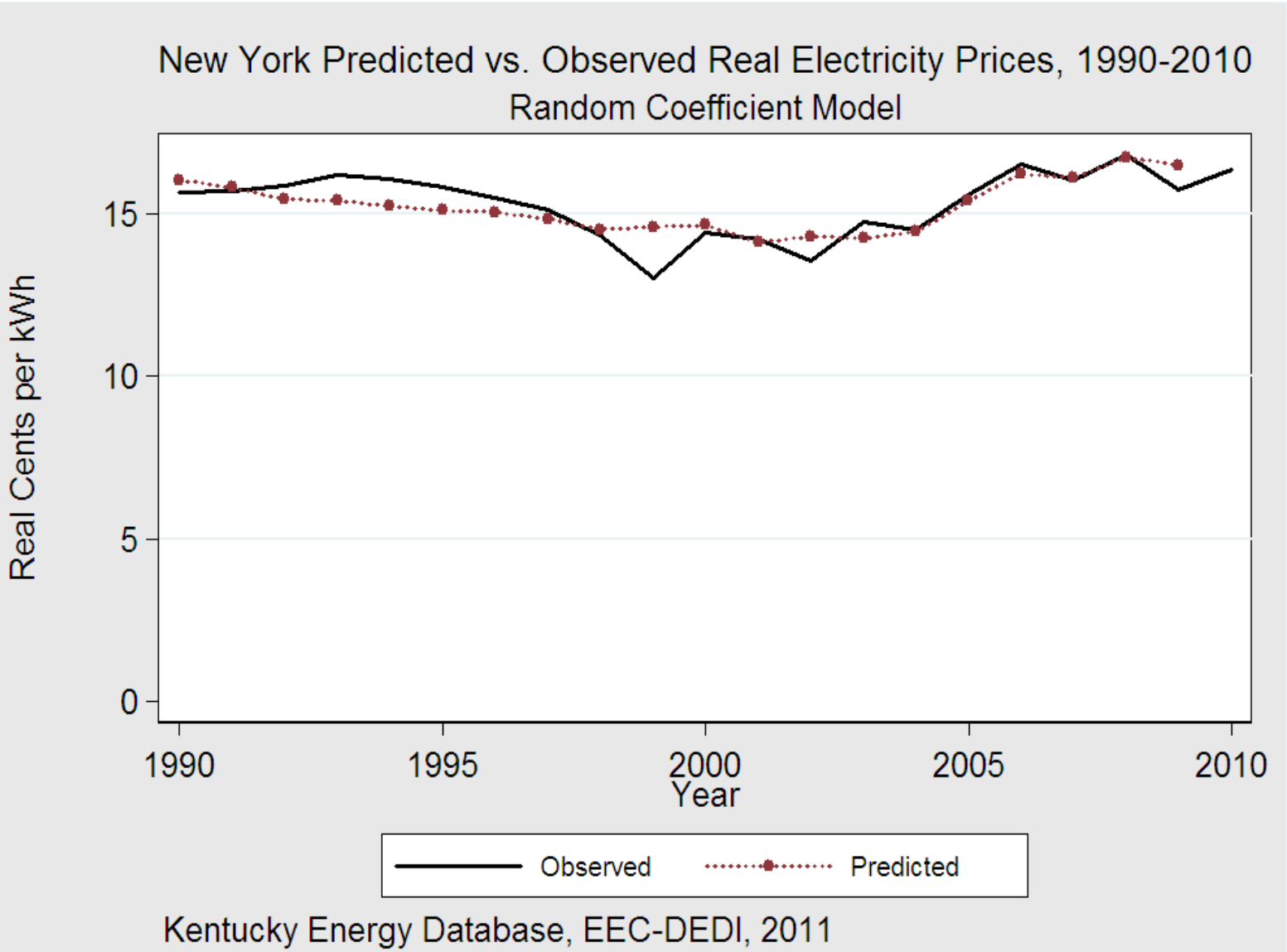
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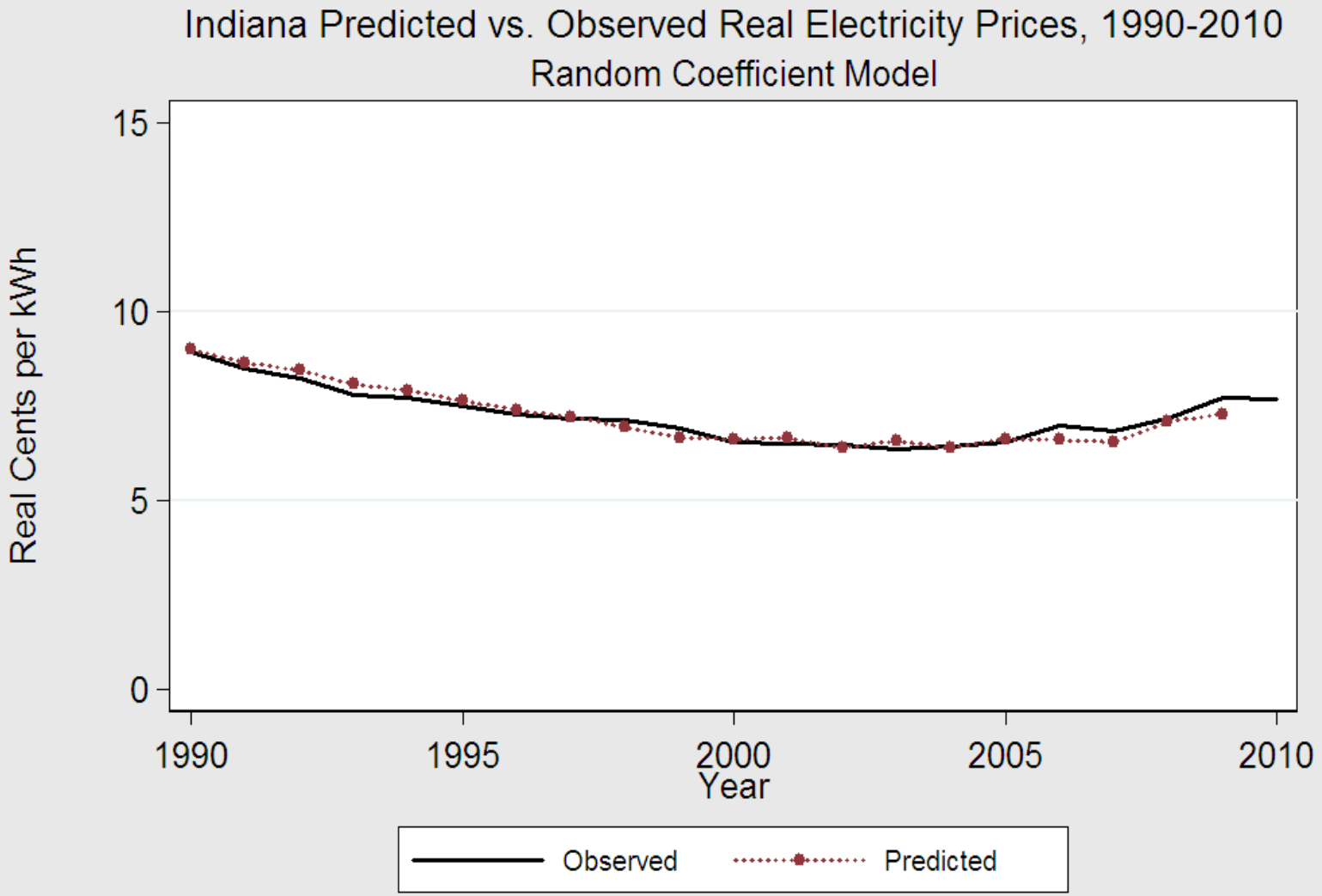
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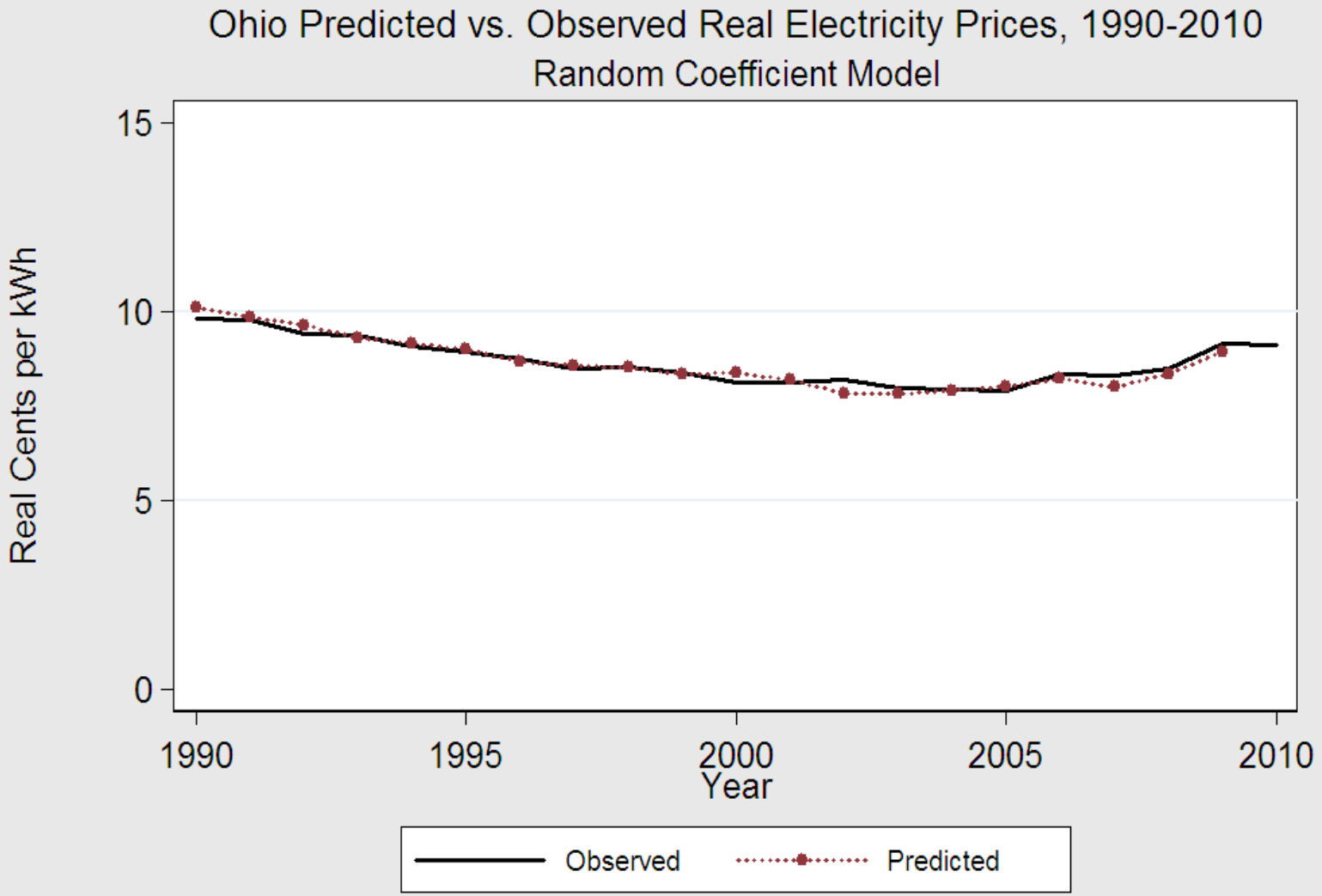
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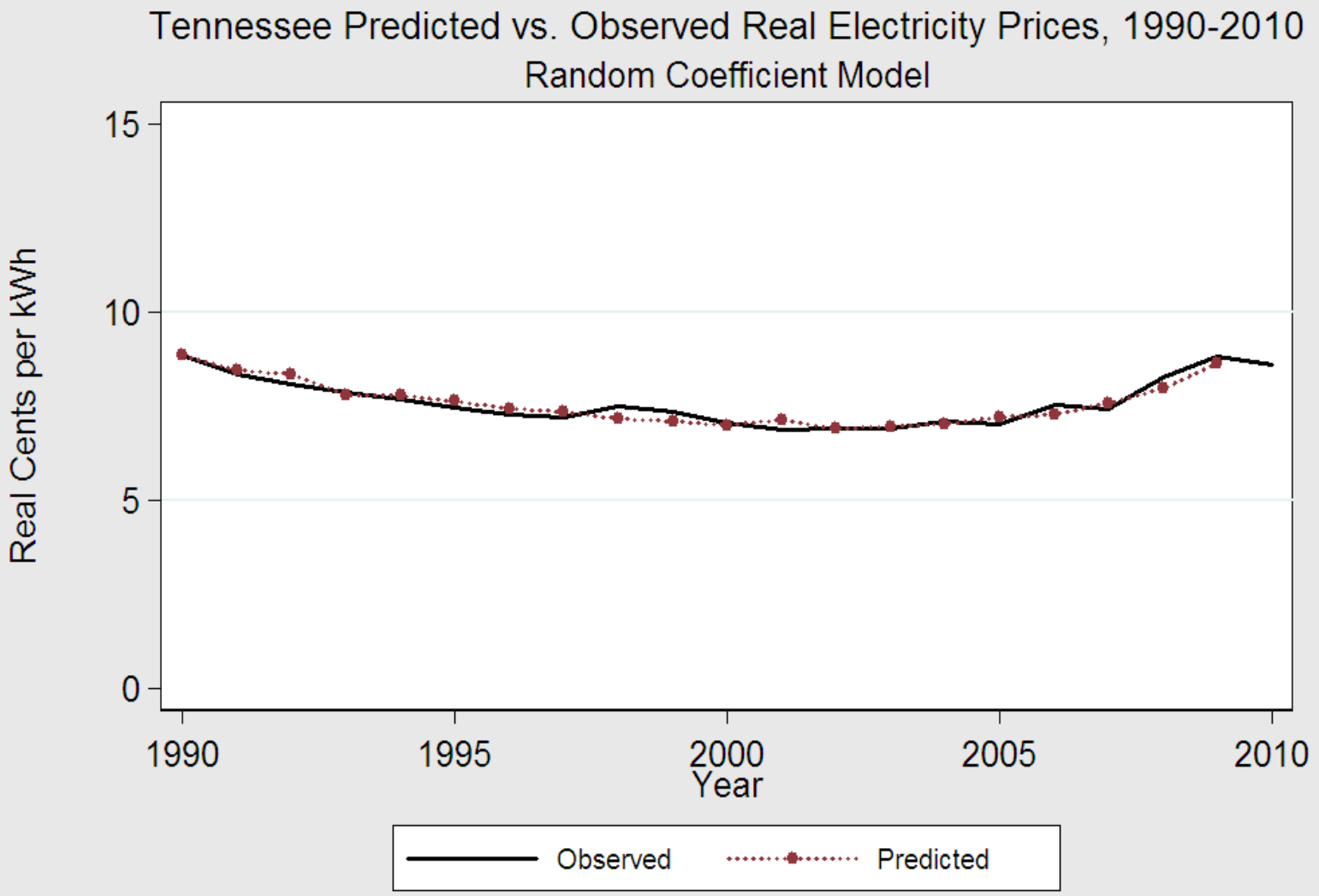
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Fixed Effect Estimation for Real Price

Fixed Effect	Paramater	p-value
Intercept	136.92	<0.0001
year	-0.06556	<0.0001
coal	2.5845	0.006
cleid_r	1.4891	<0.0001
hydro	1.1695	0.2776
gas	2.0658	0.0299
ngeid_r	-0.03606	0.2017
GAS_NGEID_R	0.4899	<0.0001
nuke	3.9876	<0.0001
wind	13.9024	<0.0001
biomass	18.436	<0.0001
estcp_pc	-198.3	<0.0001

Conclusion

Random Coefficient Model produces predictions that match the observations consistently well for most states including Kentucky.

Thank You!